# 8. *The* Islay Anticline (Inner Hebrides).

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[Plate XII—Geological Map.]

Contents.



## I. Introduction.

As compared with the publications of the Geological Survey,[1] the present paper includes the following new features:—

(1) Direct structural evidence is offered of the superposition of the Lower Torridonian sediments of the Rhinns of Islay upon the Lewisian Gneiss of the southern part of that peninsula. Dr. Peach and Mr. Wilkinson were not apparently on the outlook for big inversions, apart from such as are introduced by thrusts, and so their interpretation of the structure required confirmation.

(2) The Loch Gruinart Fault is recognized, and its possible correlation with the Great Glen Fault discussed. No dislocation is suspected in this position

[1] See Bibliography, § IV, p. 159.

by the Survey authors, but Mr. George Barrow, in conversation, has suggested that an important thrust separates the Rhinns from the rest of Islay.

(3) Collateral evidence is afforded of the existence of the Loch Skerrols Thrust.

(4) The Maol an Fhithich Quartzite is separated from the Islay Quartzite.

(5) The comparatively simple anticlinal structure of North Islay, as illustrated in Sections A & B (Pl. XII), is traced in detail. In the Survey description Dr. Peach and Mr. Wilkinson recognize the anticlinal structure of that part of the district which is included within the horseshoe outcrop of the Dolomitic Group; but they correlate the quartzite beyond this outcrop with the quartzite inside, and assume that the Dolomitic Group is everywhere preserved in synclines. The structural relations, although very clear in the field, are not very satisfactorily represented in the official 1-inch map, since certain of the faults are incorrectly drawn and dip-arrows are for the most part omitted.

(6) The 'Islay Memoir' leaves indefinite the relationship of the Portaskaig and Port nan Gallan Conglomerates, and also that of the North Islay and East Islay Quartzites. The omission is intentional, but does not correspond with any doubt entertained by the writers themselves—as may be judged, for instance, from Dr. Peach's later descriptions of Scarba. I agree with Dr. Peach in considering the rocks of North Islay and East Islay identical in these two instances.

(7) The quartzite of East Islay is shown to be interstratified between the Portaskaig Conglomerate and the Port Ellen Phyllites (Section C, Pl. XII). In the Geological Survey Memoir this quartzite is described as lying in a syncline, and the conglomerates on its two sides, which I distinguish under the names of Portaskaig and Scarba respectively, are correlated, as are also the Mull of Oa and Port Ellen Phyllites.

(8) Satisfactory evidence is given showing that the Portaskaig Conglomerate is younger than the Islay Limestone. Many, if not all, the statements bearing upon this point in the 'Islay Memoir' do not stand examination in the field. It may be added, however, that Dr. Peach's observations in the Garvellachs furnish strong and reliable support to this contention.

(9) The Jura Slates—a minor group, first separated in my official description of Jura—are identified in Islay, where previously they had been regarded as Port Ellen Phyllites exposed along the course of an anticline. The matter is of considerable importance, for on the southern coast of Islay there is very good evidence that these slates are older than the conglomerate and quartzite lying between them and the outcrop of Port Ellen Phyllites farther east. According to my interpretation of the stratigraphy, this points to the Islay Quartzite being older than the Port Ellen Phyllites, whereas in the 'Islay Memoir' the opposite conclusion is arrived at.

(10) Taking the evidence afforded by the archipelago as a whole, one is forced to dissent from Dr. Peach's correlation of the Garvallach and Scarba Conglomerates, and also from his view that the Scarba Conglomerate is the oldest part of the Scarba Quartzite.

(11) The Degnish Limestone is described, in the Geological Survey Memoir that deals with the northern part of the district, as occurring in a syncline with Easdale Slates on both sides. I have failed to find anything to represent these slates on the east side of the limestone.

(12) Particular care has been taken to distinguish clearly between observation and inference. In reading the Geological Survey memoirs dealing with Islay and the islands north of Jura, one is generally at a loss to know whether the folds so frequently mentioned have been traced in the field, or whether they form part of the theoretical interpretation.

The above enumeration of addenda and corrigenda will give a very false impression if it conceals the great obligation under which Dr. Peach and Mr. Wilkinson have placed all who are

interested in Highland geology. For my own part, I found their maps and memoirs indispensable for the study of the district in a limited time. [As originally presented, my paper contained a historical introduction, tracing the progress of research from Macculloch's days onward; but this has been withdrawn, as I am advised that it is unnecessary in view of the information already supplied in the Geological Survey Memoirs.[1]]

I may now briefly indicate my own connexion with the district. In 1902 I had the extreme good fortune to receive my Survey training from Dr. Peach, who was at that time engaged upon the investigation of Scarba and the neighbouring islands to the north. The delight of the experience I shall never forget.

In 1907, the year which saw the publication of the Islay Memoir, Mr. W. B. Wright and I were sent to map Colonsay. We were supplied with advance proofs of the Islay Memoir and with the original field-maps, and were instructed to visit the Rhinns in order to acquaint ourselves with its geological structure and succession, because Dr. Peach and Mr. Wilkinson had already established a close connexion between Colonsay and this part of Islay. After a few days spent officially in the Rhinns, we took holidays and separated—Mr. Wright to study the raised beaches, and I, on Dr. Peach's advice, to familiarize myself with the rocks overlying the Loch Skerrols Thrust. I made a complete tour of the coast-sections and many of the inland exposures. As a result, I realized the necessity for modifying the views set forth in the Memoir along the lines indicated in the present paper. I wrote down my conclusions, but deferred publication until I could return to the island and satisfy myself in sufficient detail as to the nature of the faulted western limb of the Islay Anticline north of Bridgend. As chances afforded, I added to my observations in succeeding years, but did not obtain a satisfactory opportunity to work out this particular feature of interest until I took a holiday in the island in 1913. At this time I also revisited the Rhinns, in order to assure myself that the Lewisian Gneiss does really pass below the Torridonian on the north, and is not affected by large-scale inversion.

But to return to the year 1907. I had other districts to visit before following Mr. Wright to Colonsay, and by the time I arrived he had already determined the major features of the geology. Not long afterwards he made the interesting discovery of two earth-movements affecting the cleaved sediments of the island. An account of his researches in this direction is published in the Journal of this Society and in the Geological Survey Memoir dealing with Colonsay.

In 1908 I officially revisited Shuna in company with Mr. Maufe, and we found it impossible to agree with Dr. Peach's view that the Degnish Limestone is separated from the Ardrishaig Phyllites

[1] Sections 1 and 2 of the Detailed Descriptions, which follow, have also been recast.

by black slates. In 1913 I visited Degnish for the first time, and came to a like conclusion.

In 1910 I was sent by Dr. Horne to Jura to collect material for the Geological Survey Memoir then in preparation. In a fortnight I examined the whole of the coast-sections and various inland exposures.

## II. Detailed Descriptions.

### (1) Geology of Colonsay and Islay, West of the Loch Skerrols Thrust.

A very brief description of the geology of the western part of the Islay Archipelago will suffice. My observations in Colonsay and Oronsay have already been published, in conjunction with Mr. Wright's, in the Survey memoir on those islands, while my knowledge of the western portion of Islay itself is not sufficient to warrant a detailed account at the present juncture.

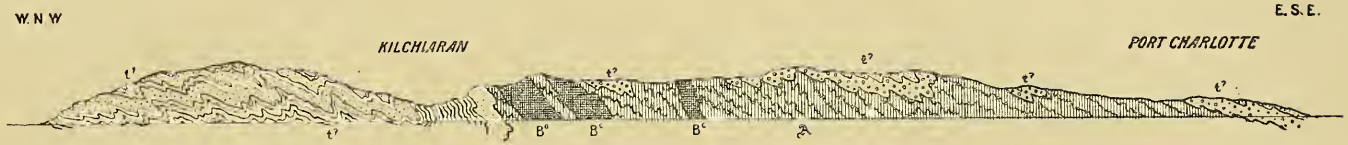
Two outcrops of crystalline rocks—a large one in the south of the Rhinns and a small one in the north of Colonsay—have been referred to the Lewisian Complex by Thomson [3, p. 221][1] and Wright respectively. In contact with the Lewisian lies a mass of varied sediments placed by such good judges as Dr. Peach and (subsequently) the late Dr. Clough in the Lower Torridonian System. In both localities the junctions between the Lewisian and Torridonian rocks are much sheared, but this is not a sufficient reason to suspect that the original relationship has been materially altered by thrusting. In fact, Dr. Peach and Mr. Wilkinson have detected what appears to be a true basement-conglomerate at various places near the edge of the Torridonian in the Rhinns. The best exposure of this conglomerate is at Dun Mideir.

From clearly-defined gentle north-easterly pitches which I have observed in traversing the Lower Torridonian sediments lying north of the gneiss-outcrop in the Rhinns of Islay, it seems certain that the gneiss sinks in this direction beneath a covering of Torridonian disposed in a series of sharp but shallow folds (fig. 1, p. 136). I have found north-easterly pitches well marked in the southern part of the sedimentary area, and again between Sanaigmore and Ardnave Point (where shown in Pl. XII). Probably a fairly uniform pitch prevails throughout the whole of the peninsula. It is unfortunate that the lines separating psammitic and pelitic sediments in Sheets 19 & 27 of the Geological Survey map are not drawn with sufficient accuracy to be of assistance in following out the structure; but I am strongly of opinion that the thickness of the sediments in the Rhinns is very considerable, and that the highest stratigraphical horizon is met with at Ardnave Point.

Similar gentle north-easterly pitches continue through Oronsay and the southern part of Colonsay, introducing higher groups, probably, than those encountered in the Rhinns. Mr. Wright and

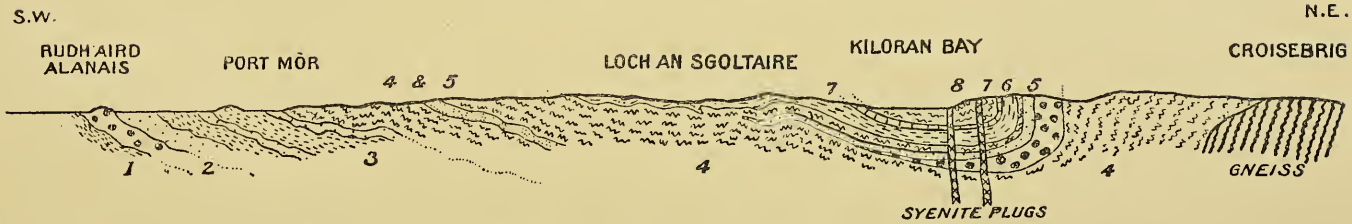
[1] Numbers in brackets refer to the Bibliography, § IV, p. 159.

Fig. 1.—*Generalized section across the Rhinns of Islay (after B. N. Peach & S. B. Wilkinson, 7, p. 20), on the scale of $1\frac{5}{8}$ inches to the mile.*




[A = the fundamental complex of Lewisian; $B^G$ = Basic rocks of the Lewisian; $t$ = Lower Torridonian.]

Fig. 2.—*Section across Colonsay (after W. B. Wright & E. B. Bailey, 14, p. 21), on the scale of 1 inch to the mile.*




[Nos. 1–8 refer to groups of the Lower Torridonian, of which 7 is the Colonsay Limestone.]

Note.—Figs. 1 & 2 are reproduced by permission of the Controller of H.M. Stationery Office.

I have traced an upward succession culminating at last in two isolated synclines—the one at Kiloran Bay, the other at Scalasaig. The sediments of Oronsay and Colonsay have been estimated at about 5000 feet in thickness.

Beyond Kiloran a descending sequence is introduced with very high dips, and before long one meets with the outcrop of gneiss already mentioned (fig. 2, p. 136). It is natural to interpret this gneiss as emerging from beneath the neighbouring Torridonian sediments, and continuous underground with the gneiss of Islay.

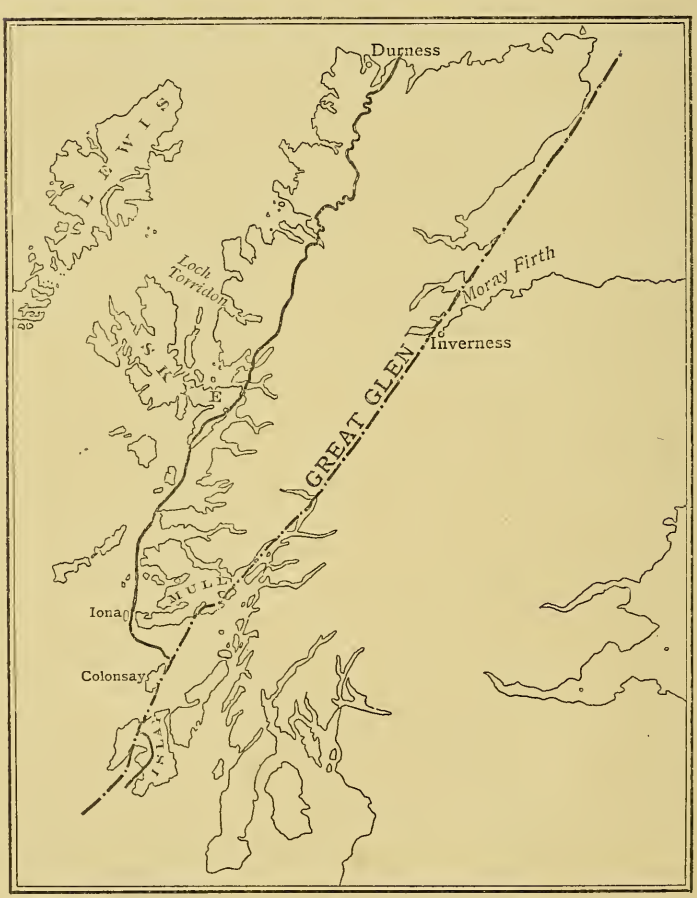
When we take into consideration the great thickness of the Lower Torridonian sediments of Colonsay and Islay, we find ourselves bound to postulate an important dislocation along the hollow of Loch Gruinart; for, immediately east of this hollow, we find the Bowmore Sandstone and Islay Quartzite, divisions unrepresented in even the deepest of the Colonsay synclines. For this dislocation I propose the name of the Loch Gruinart Fault. In the Islay Memoir the existence of such a fault is not recognized, and a description is given of what is supposed to be an unbroken contact between the Bowmore Sandstone and the Lower Torridonian on the shore at Gortan. When I visited this section I was unfamiliar with the rocks, and my opinion is consequently of little value; but I am inclined to doubt the Bowmore Sandstone of this restricted exposure. If, however, the correlation be correct, then it would appear that the Loch Gruinart Fault, or a branch of the same, runs slightly to the west of the Gortan foreshore. Otherwise the north-easterly pitch, characteristic of the Rhinns, would carry the Bowmore Sandstone outcrop across the Rhinns long before Ardnave Point was reached.

Without going into details, it seems quite probable that the Loch Gruinart Fault is the south-westerly continuation of the Great Glen Fault. All that is certain is that the Great Glen Fault must pass very close to Colonsay on the one side or the other; and so it is reasonable to connect it with the Loch Gruinart Fault, for both dislocations agree in having a powerful downthrow to the south-east. An additional reason for drawing the Great Glen Fault south-east of Colonsay rather than north-west is illustrated in fig. 3 (p. 138). In the North-West Highlands, wherever undoubted Torridonian rocks are found, they underlie the Moine Thrust. It is probable, therefore, although by no means certain, that the Torridonian rocks of Colonsay and the Rhinns of Islay occupy a similar position. The outcrop of the Moine Thrust was identified by Clough with fair certainty as near Colonsay as the Sound of Iona [C. T. Clough in 14, p. 77]; and, if it is to clear Colonsay after leaving the Sound, it must bend sharply south-eastwards, as shown in fig. 3. According to this interpretation, the Great Glen Fault can scarcely run between the Sound of Iona and Colonsay, for the effect of this fault, with its great downthrow to the south-east, would be to displace the outcrop of the Moine Thrust south-westwards. On the other hand, it does seem likely that the fault passes south-east of Colonsay,

since, on crossing the line laid down for it in fig. 3, one finds rocks of the Highland Schist Complex extending south-westwards as far at least as the outcrop of the Loch Skerrols Thrust.

Mention has already been made of the Bowmore Sandstone. As exposed along the shore between Bowmore and Laggan, this group

Fig. 3.—*Suggested continuation of the Great Glen Fault across Islay, with the Moine Thrust on the north-west side perhaps equivalent to the Loch Skerrols Thrust on the south-east side (in Islay).*




consists of compact, hard, fine-grained sandstone, weathering with brown surfaces, but grey on a fractured face. A very occasional solated pebble of quartz or felspar can be detected, sometimes of air size. The rocks are extremely homogeneous, and therefore the

bedding is very faintly marked. They are much shattered, as well as considerably sheared. Near Laggan their weathering tints are paler than usual, and some of the group might be styled 'fine felspathic quartzite.' At Blackrock pebbly beds occur, and are represented by slides 6231–6236 in the Geological Survey collection.

As mentioned above, there is often a difficulty in making out the dip of the Bowmore Sandstone. Appearances certainly suggest a very general inclination towards the south-east at angles varying, according to Mr. Wilkinson, between 10° and 40°.

Several competent judges, including Dr. Peach, have been impressed by the resemblance of the Bowmore Sandstone to the Middle and Upper Torridonian. The recognition of the Loch Gruinart Fault does not greatly weaken the correlation which has been based upon this similarity. If, indeed, the Bowmore Sandstone belongs to the southern continuation of the Torridonian, then it is extremely likely that the Loch Skerrols Thrust is the same as the Moine Thrust of the North-West Highlands.

It is well to bring this section to a close on a note of warning. There is something very attractive in the view propounded above that the Lewisian and Torridonian rocks of Colonsay and Western Islay belong to the disturbed foreland up on to which the Moine Nappe has ridden. And also in the further hypothesis that the Moine and Loch Skerrols Thrusts are identical, in which case one must suppose that the Moine Thrust has transgressed from its position in the North-West Highlands under Moine Schists—extending into Mull—until in Islay it lies directly beneath Dalradian Schists of the Central Highlands. There is, however, no abrupt change of metamorphism on crossing the Loch Skerrols Thrust, for the so-called 'schists' of Islay are included in an area of extremely low metamorphism which embraces much of Argyllshire. On this account, Dr. Peach is encouraged to recognize in the Torridonian of Colonsay and West Islay the southward continuation of the Moine Schists in an unmetamorphosed condition, and to refer them to the Moine Nappe rather than to the underlying foreland. This interpretation is, of course, only a part of Dr. Peach's well-known though but partly-published theory, in which he maintains the Torridonian age of the Moine Schists as a whole.

## (2) The Loch Skerrols Thrust.

The Bowmore Sandstone passes eastwards beneath the Islay Quartzite. The junction can be followed with approximate accuracy as far south as Bowmore. Beyond this it is completely covered beneath superficial deposits—in fact, it is quite doubtful whether quartzite persists along the eastern margin of the Bowmore Sandstone.

The recognition of the Loch Skerrols Thrust by the officers of the Geological Survey was due in the first place to the marked deformation and mylonitization of the Islay Quartzite and Bowmore Sandstone at their mutual contact. The mechanical evidences are

well described by Mr. Wilkinson, who points to the 'drawing-out' of the quartzite along lines varying between west 30° north and north 10° west. The 'drawing-out,' where I have seen it, is of the nature of striation upon shear-planes; at Loch Skerrols it runs north 30° west.

The existence of the Loch Skerrols Thrust can be demonstrated on quite other grounds. It is the purpose of the present paper to show that the Islay Quartzite is folded in an anticline overturned north-westwards. In the heart of the anticline are the Portaskaig Conglomerate, Islay Limestone, etc.; on the south-eastern flanks of the anticline lie the Port Ellen Phyllites. The absence of the last-named group along the west side of the anticline, where the quartzite directly overlies the Bowmore Sandstone, can only be accounted for by invoking a thrust. The north-westward overturning of the anticline above the thrust-plane strongly suggests that the movement along the Loch Skerrols Thrust is in the same sense as that along the Moine and other well-known thrusts farther north. The possible equivalence of the Loch Skerrols and Moine Thrusts has already been touched upon in the previous section.

### (3) Rocks above the Loch Skerrols Thrust, as far East as Luing.

The metamorphism of the rocks overlying the Loch Skerrols Thrust is of so low a grade that it is important to have clear evidence of the identity of these rocks and the Dalradian Schists of the mainland. This evidence was obtained long ago by Macculloch [1, vol. ii, p. 159], when he discovered the Portaskaig and Garvellach Conglomerate full of 'granite' (nordmarkite) and 'limestone' (dolomite) boulders, and correlated it with the Schiehallion Conglomerate of Perthshire. The significance of Macculloch's comparisons has of late years been heightened, as a result of Dr. Flett's examination under the microscope of the boulders included in these conglomerates [12, p. 75].

### (3 *a*) Maol an Fhithich Quartzite.

This group consists of fine-grained quartzite. A pocket-lens reveals the clastic structure, and further shows that some of the minute quartz-pebbles are blue in colour. Near its junction with the succeeding phyllites the quartzite is intensely sheared. Mr. Wilkinson regarded the outcrop as a faulted outlier of the main Islay Quartzite; but this view may be set aside, as the quartzite and the adjacent phyllites are interfoliated and apparently also, to some extent, interbedded.

### (3 *b*) Mull of Oa Phyllites.

These phyllites are prevalently of a dark-grey tint and rather sandy texture. Colour-striping is common, and is especially well

seen in the shore-section of the south-eastern corner of Laggan Bay. Grey or greenish phyllites are exposed on the foreshore here, and are constantly interlaminated with very dark seams approaching black.

Cream-coloured sandy dolomites are common in some sections, and may be examined in the cliffs a mile north of the Mull of Oa. The lower [1] bands of the grey Islay Limestone undoubtedly make their first appearance intercalated in the upper portion of the Mull of Oa Phyllites. There are also occasional outcrops of white limestone and associated fine-grained quartzite, which appear to be referable to a like position.

Rough dark-grey, or blackish, slates are quarried at Esknish, and belong to a horizon somewhat below the main mass of Islay Limestone.

The group is much more sheared in the southern part of its outcrop than in the northern, where bedding surfaces are sometimes found glistening with clastic micas.

### (3 *c*) Islay Limestone.

The limestone-beds, here classed together, make their first appearance in the upper portion of the Mull of Oa Phyllites, and attain a well-defined maximum at the summit of the group. They are somewhat sandy in composition, and generally dark grey, blue, or black in colour. Oolitic structure is well developed in one or more bands, which have been noted by Mr. Wilkinson at widely-separated points along the limestone-outcrop. Thomson examined the oolites microscopically in the hope of finding fossils, but without success [3, p. 216].

The uppermost bed of the Islay Limestone, near Loch Lossit, is a rather pale-grey rock, which, on testing, proves to be dolomite. I think that dolomite also occurs, north-east of Bridgend, as cream-coloured bands interstratified with the ordinary grey type of Islay Limestone. I did not test them, but they are very similar in appearance to dolomites that occur on higher horizons in the island. Such exceptions, however, do not vitiate the general rule clearly stated by Mr. Wilkinson, that the Islay Limestone is a true limestone; whereas the calcareous beds of the Portaskaig Conglomerate and the Dolomitic Group of the Islay Quartzite are just as definitely dolomite.

Locally—as, for instance, west of Esknish—it appears that certain bands of the limestone become conglomeratic. Fragments of oolitic limestone are crowded together, sometimes cemented in an oolitic matrix. It seems that these beds, if more than one exist, occur near the top of the limestone group. Mr. Wilkinson regards them as belonging to the Portaskaig Conglomerate, and describes their outcrops as outliers; but, as careful search fails to

[1] The terms lower and upper used in this connexion are justified by structural considerations developed in the sequel.

reveal any bed of the kind at the neighbouring margin of the main conglomerate, I am disposed to regard them as interstratified members of the limestone group.

Mr. Wilkinson has traced the outcrop of the Islay Limestone, in a curve like a horseshoe, from near Bowmore to the Mull of Oa[1]; and has thus demonstrated quite clearly that a fold-axis runs up Central Islay. It is true that the limestone-outcrop, as drawn upon the map, is discontinuous; but many of the interruptions are due to the masking by Drift of portions of the district.

### (3 *d*) Portaskaig Conglomerate.

I cannot do better than quote the words with which Dr. Peach concludes his description of the conglomerate as exposed in the Garvellachs:—

'The study of the rocks on this group of islands tends to confirm Macculloch's sagacious and far-seeing correlation of this boulder-bed with that of Islay and Schiehallion.'

A very interesting feature of much of the Portaskaig Conglomerate in Islay is its extremely glacial aspect. Large portions of it are unbedded boulder-clay charged with far-travelled boulders. Thomson has urged that it must be of glacial origin, and states that he found a typical striated boulder of quartzite embedded in it [3, p. 211]. I was not equally fortunate, however, although I searched the conglomerate carefully with the same end in view. It is not clear why striated boulders should be difficult to find if the boulder-clay is of glacial origin; for, although the matrix is cleaved, the boulders themselves are often quite unaltered by later movement. There is another difficulty to be faced by the glacial theory: much of the conglomerate is a stratified deposit, and is interbedded with layers of quartzite and dolomite, from which latter it has derived fragments as a result of obviously non-glacial 'contemporaneous erosion.' In the light of these sections one cannot help wondering whether it is necessary to invoke glaciation in order to account for any part of the conglomerate.

Islay.—Splendid exposures of the conglomerate occur both north and south of Portaskaig. The base of the deposit is not seen at the coast in this neighbourhood, but inland sections about Loch Lossit make good the deficiency. Here the grey dolomitic topmost bed of the Islay Limestone, previously mentioned, is overlain by a few feet of dark shale or slate with quartzose ribs, and these by the conglomerate itself. The strata are lying at very

[1] The coast exposure near the Mull of Oa is disappointing, for the limestone is bleached and reddened in the vicinity of a curious breccia, which, as Dr. Peach suggests, may be a miniature Triassic outlier. Inland exposures, however, even that of the raised-beach cliff, show the grey limestones in characteristic form, and Mr. Wilkinson has recorded oolitic beds as far south as the farm Coillabus.

low angles, and, as Mr. Wilkinson has pointed out, a cake of conglomerate catches on to Beannan Dubh, a little hill rising to the east of Loch Lossit.

The lower portion of the conglomerate is clearly an aqueous deposit, showing obvious bedding, and split up by numerous interstratified bands of quartzite and sandy cream-coloured dolomite. The upper portion, including the main mass, is unbedded, and carries its blocks, boulders, and pebbles promiscuously in a brown, clayey and sandy, somewhat calcareous (likely dolomitic) matrix.

The most conspicuous fragments in the deposit are nordmarkites, of unknown source, and pieces of cream-coloured dolomite—like the dolomite intercalations, only purer. Mr. Wilkinson has described Islay-Limestone pebbles as a feature of the conglomerate, but I spent three days in searching without finding one. It seems probable that his statement has originated on the assumption, already mentioned, that certain conglomeratic limestone-bands belong to the Portaskaig Conglomerate: whereas they appear really to be an integral portion of the Islay Limestone itself. There is no doubt, too, that the dolomite-fragments have often been reckoned as limestone.

Other rocks represented in the Portaskaig Conglomerate have been compared by Mr. Wilkinson with the Lewisian and Torridonian west of the Loch Skerrols Thrust. It is interesting to find gneisses and grits among the boulders, but I think that one should hesitate before assigning them to any particular source.

The Beannan Dubh exposures furnish invaluable evidence in determining the original order of superposition among the sedimentary groups overlying the Loch Skerrols Thrust. The sandy cream-coloured dolomites interstratified in the lower portion of the conglomerate are very prominent in this section. They have been described by Mr. Wilkinson, and their outcrop is indicated on the Geological Survey 1-inch map, Sheet 27, though too small to reproduce in Pl. XII. A careful examination of these beds shows that they have suffered 'contemporaneous erosion,' and have yielded numerous fragments to the conglomerate; and the rule seems to be that the fragments of any particular bed of dolomite enrich the immediately overlying bed of conglomerate.

One of the dolomite-bands is especially noteworthy. It is of a paler tint than usual, and is well exposed for a couple of hundred yards along the south-eastern face of the hill. It rests with an even base upon shales, but is of very irregular thickness, as if its upper surface had suffered from erosion. The overlying rock is a brown, gritty, well-bedded dolomite, which extends downwards into the cavities characterizing the top of the white dolomite below. Moreover, the lower part of the brown dolomite usually contains numerous large fragments of the underlying stratum—in fact, there is often a foot or two of coarse breccia between the two layers, consisting of angular blocks of dolomite set in a sparse, brown, gritty matrix.

Now, this evidence, carefully considered in the field, left no

doubt in my mind that the Beannan Dubh succession is right way up. But in Beannan Dubh Portaskaig Conglomerate occurs superimposed upon Islay Limestone. Accordingly, I take it that the index on Pl. XII gives the rock-groups in their original order.

Thus it is proved that the core of the Islay Fold is constituted of the older portion of the Islay Schist succession. It does not, however, follow at once that the fold is an anticline, for in the Highlands we must be prepared to meet with folds affecting inverted sequences, so that additional evidence is required before coming to any conclusion in this matter. Meanwhile, it may be noted that the mapping of the Portaskaig Conglomerate further demonstrates the existence of the Islay Fold, for Mr. Wilkinson has succeeded in tracing the conglomerate intermittently from near Bowmore to Port nan Gallan, east of the Mull of Oa. I may add that I have visited all the known exposures, except the one near Bowmore; between this last and Laggan Bay the solid rocks are completely hidden under superficial deposits.

In the northern part of the island the Portaskaig Conglomerate reaches a thickness of some hundreds of feet. But even here it varies considerably in character, and in some of the outcrops north of Bridgend crystalline boulders are so scarce that one may walk a quarter of a mile before meeting an example; the dolomite-fragments are more universally abundant. In the exposures on the western side of the fold the cleavage is very intense, giving a shaly appearance to the rusty weathering conglomerate.

Followed southwards along the east side of the fold the conglomerate dwindles, and rarely carries conspicuous crystalline boulders. Only in two of the southern exposures is it found richly charged with the typical nordmarkites. These two occur at Beinn Bhan and Port nan Gallan respectively [7, pl. v]. At the former the unbedded, and at the latter the bedded, types of the conglomerate are exposed. Intervening occurrences of the group are as follows from north to south:—

(1) Immediately north-east of a farm, Balvickar (2 miles north-west of Port Ellen), are strong beds of pure cream-coloured dolomite, separated by cleaved, reddish-brown, very fine-grained conglomerate or grit presenting the impure, sandy, argillaceous, slightly calcareous character of the matrix of Portaskaig Conglomerate.

(2) North-east of a farm, Craigabus (2 miles west of Port Ellen), exposures occur showing cleaved, impure, muddy, calcareous, and sometimes slightly gritty rock, occasionally full of fragments of cream-coloured dolomite. A bed of similar dolomite is seen close at hand.

(3) In a road-metal pit south-south-east of a farm, Coillabus (shown on Pl. XII), there is a sandy muddy conglomerate, with quartz-grains and dolomite-pebbles. It is very like the Portaskaig Conglomerate elsewhere, and seems to be underlain by dolomite and quartzose schists.

(4) East of Loch Ardachie (1 mile south-west of Coillabus), the succession just described in (3) is seen to better advantage. A conglomerate with many dolomite pebbles overlies a bed of dolomite which is separated from the Islay Limestone by a band of quartzite.

The Port nan Gallan outcrop has been figured in the Geological Survey Memoir [7, fig. 3, p. 40] to illustrate the unconformity

which, according to Dr. Peach and Mr. Wilkinson, exists between the Portaskaig Conglomerate and the Islay Limestone. Unfortunately, the figure is wrongly drawn, for it shows the basal layer of the conglomeratic series obliquely truncating the bedding of the limestone. This is not the case: for, although a plane of discordance separates the two groups, the conglomerate and limestone have identically the same dip. The plane of discordance may, perhaps, have been determined by erosion, as advocated in the memoir; but, if so, the section gives no clue as to which of the two groups is unconformable to its neighbour.

The Garvellachs, or Isles of the Sea.—The oldest rock exposed in the Isles of the Sea is a cream-coloured, white, or pinkish dolomite—or dolomitic limestone—accompanied in places by light-grey slaty beds. Dr. Peach has estimated the thickness of the dolomite as not less that 40 feet. The succeeding rocks are almost all conglomeratic.

On the north-western shore of the main southern island, Eileach an Naoimh, Dr. Peach discovered a beautifully-exposed anticline of the dolomite, surmounted by bedded conglomerate made up exclusively of dolomite fragments, many of them of great size (fig. 4, p. 146). Farther out from the anticlinal axis the dolomite fragments are smaller and enclosed in a dark matrix; while well-rounded boulders of rocks foreign to the islands—nordmarkite, felsite, gneiss, schist, jasper, etc.—make their appearance, sometimes in great abundance. Then follow intercalations of sandy shales, with bands of sandy dolomite and flaggy fine-grained quartzite. These are succeeded by brown-weathering conglomerates charged with dolomite- and nordmarkite-boulders. Pure quartzite is interbedded with the conglomerate, and becomes increasingly prominent at a distance from the anticlinal axis. It contains boulders similar to those that have been enumerated above, but more sporadically distributed.

The main Garvellach dolomite, which yields so many fragments to the Portaskaig Conglomerate in its vicinity, recalls in appearance the dolomite intercalations of the conglomeratic series in Islay, only it is thicker and purer. It is impossible, without boring, to decide whether the Garvellach dolomite is similarly interstratified, or whether it completely underlies the conglomeratic sequence. The interstratified dolomites in Islay, it will be remembered, have suffered from contemporaneous erosion, and therefore the erosion effects in connexion with the Garvellach bed are in keeping with either alternative.

## (3 *e*) Islay Quartzite.

North Islay.—The Islay Quartzite is not wholly represented in North Islay, as the top is wanting. In spite of this, North Islay is the most interesting portion of the archipelago from our point of view, for it enables us to realize the anticlinal nature of

Fig. 4.—*Cliff-section, 200 feet high, on the north-western coast of Eileach an Naoimh (Garvellach).* *See p. 145.*

[Anticline of dolomite, rising to 150 feet, enveloped in Portaskaig Conglomerate. The cliff faces south-westwards. Sketched from a photograph by R. Lunn, 10, pl. iv, p. 32.]

the Central Islay Fold. The following subdivisions are recognized in the Quartzite Series, in descending order :—

Pebbly Quartzite.
Upper Fine-Grained Quartzite.
Dolomitic Group ('Fucoid Beds' of the Geological Survey Memoir), with often a massive quartzite intercalation ('Pipe Rock' of the Memoir) near the base.
Lower Fine-Grained Quartzite.

In regard to the two lower subdivisions and their relations to the Portaskaig Conglomerate, the above is in agreement with the succession as stated by Mr. Wilkinson. But, whereas he believes that the Dolomitic Group is the highest stratigraphical division preserved in the island, I propose to show that it is overlain by much the greater portion of the Islay Quartzite.

The structure and succession of the district can be determined equally well along the coast or inland. The coast-section furnishes a good introduction, and will be considered first.

*Coastal traverse from Portaskaig to Loch Gruinart.*— The Lower Fine-Grained Quartzite succeeds the Portaskaig Conglomerate with an even, moderate northerly dip in two clear sections (repeated by normal faulting) on the shore north of Portaskaig. The quartzite here is very fine-grained, pure though slightly felspathic, vitreous, well-bedded, and ripple-marked. It must be some hundreds of feet thick. In the northern exposure thin conglomeratic seams occur towards the top, one bed containing pebbles of nordmarkite, quartzite, and shale.

I have seen specimens from the Islay Quartzite which could be placed right way up with confidence, because they carried narrow-crested broad-troughed ripple-marks. During my earlier visits I had not realized the value of ripple-marks in determining the original order of superposition of a little-altered series of sediments. On my last visit my time at Portaskaig was unfortunately too short to enable me to investigate the point satisfactorily. There is no doubt, however, that this line of research is a very promising one in Islay and elsewhere.

The succeeding Dolomitic Group consists, in the Portaskaig sections, of the following subdivisions, in descending order :—

Thick zone, very largely made up of buff-weathering, banded, impure dolomitic beds, with a very small proportion of grey or blue limy seams; also dark and silky-grey, impure quartzose slates; and, towards the top, important beds of pure, cream-coloured and white dolomite.

Minor band of well-bedded, massive, fine-grained quartzite, about 100 feet thick.

Grey silky phyllites, sandy-grey flags, banded, flaggy, fine-grained quartzite (one pebbly layer has been noticed), alternating with calcareous or dolomitic flags and fine-grained quartzite. Almost every bed ripple-marked.

Some of the flags are sun-cracked in the manner that is so common among the Orcadian Flags of Old Red Sandstone age. This feature was remarked upon by Thomson, as also the presence of

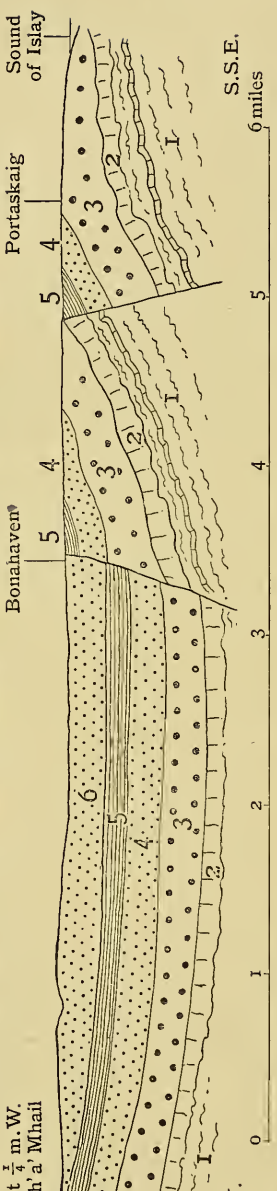



Fig. 5.—*Section from Portaskaig to the northern coast of Islay (thicknesses exaggerated).*

[1 = Mull of Oa Phyllites (with limestone-band); 2 = Islay Limestone; 3 = Portaskaig Conglomerate; 4 = Lower Fine-Grained Quartzite; 5 = Dolomitic Group; 6 = Upper Fine-Grained Quartzite.]

possible worm-tracks and rain-pits. In the massive quartzite Dr. Peach records worm-pipes similar to the 'small pipes,' 'ordinary pipes,' and 'trumpet-pipes' characteristic of the three zones of the 'Pipe-Rock' of the Durness Quartzite. I could not find these worm-pipes during the time at my disposal, and it must be remembered that structures suggestive of worm-pipes are sometimes open to a variety of interpretations. I have seen small, rounded, sandy bodies interrupting the bedding of the Islay Quartzite about 2 miles south-west of Beinn Bhan (South Islay), which strongly recall the choked openings of worm-pipes; but I was never able to trace pipes down from them into the rock below. Similar 'small rounded concretions on the weathered surfaces' of some of the quartzite near the western coast of Scarba have been called 'pseudopipes' by Dr. Peach because of their 'simulating the so-called "pipes."'

The Dolomitic Group clearly dips off the Lower Quartzite division in both sections along the coast north of Portaskaig. The more northerly exposure is terminated by the Bonahaven Fault. So far there is no difference of opinion in regard to the structure of the coast, and the part of fig. 5 south of Bonahaven is little more than a copy of a section given in the Survey Memoir.

The Bonahaven Fault introduces the Upper Fine-Grained Quartzite — a pure, slightly-felspathic, well-bedded quartzite with vitreous fracture;

it is immensely thick and very white, whiter probably than the Lower Quartzite.

The authors of the Geological Survey Memoir on Islay regard all the quartzite of the island as belonging to the subdivision under the Dolomitic Group, and, therefore, refer to the Bonahaven Fault as having 'a downthrow to the east.' A glance at the map, however, shows that the fault, all along its inland course, has an important downthrow to the north-west. Thus it appears that the quartzite introduced into the coast-section by the Bonahaven Fault structurally overlies the Dolomitic Group.

The superposition of the Upper Fine-Grained Quartzite is still more obvious on the northern coast, west of Rudh' a' Mhail, where the Dolomitic Group makes its appearance as an isolated inlier with gentle anticlinal dips.

The quartzite west of the inlier continues with westerly dips, averaging about 35°, until truncated by a fault, inclining steeply to the east, and excellently exposed for over 100 feet in the cliffs of the raised beaches. Just east of the fault on the foreshore the quartzite includes a conglomeratic bed with lumps of quartz in a quartzitic matrix. It has been described as carrying granite-pebbles also, but I do not feel confident that such is the case. The authors of the Geological Survey Memoir confused this conglomerate with the conglomerate already described as occurring at the top of the Lower Quartzite; and, not noticing the fault, imagined that a normal passage existed from it up into the Dolomitic Group, for the latter appears immediately on the west.

The Dolomitic Group, which occupies the shore west of the fault, undulates at low angles until, passing over an anticline, it dips somewhat steeply westwards at an average angle of about 40°, and once more passes beneath the Upper Fine-Grained Quartzite. The rocks near the junction on the foreshore are broken by a shatter-belt, and this has led to the insertion of a fault on the Geological Survey map. But the apparent superposition of the quartzite over the Dolomitic Group cannot be explained away by a fault, since the actual contact of the two groups may be seen intact where a path goes behind an old sea-stack of the raised beach.

This is the last appearance of the Dolomitic Group on the coast. The whole of the northern cliffs to the westward are fashioned out of quartzite dipping north-north-westwards at angles of about 45°. At Gortantoid Point, east of Loch Gruinart, the Upper Fine-Grained Quartzite passes under Pebbly Quartzite, distinguished by numerous layers of quartz-pebbles, of rather small size and often blue in colour, and by scattered, big, rounded pebbles, also quartz. The pebbly layers and pebbles are merely features in a prevalently fine-grained quartzite exactly like that of the underlying group.

Three important results follow from the coastal traverse detailed above :—

(1) The groups—Portaskaig Conglomerate, Lower Fine-Grained Quartzite, Dolomitic Group, Upper Fine-Grained Quartzite, Pebbly Quartzite—are in

ascending structural sequence; this proves conclusively that the fold, running up Central Islay and determining the horseshoe outcrops of the Islay Limestone and Portaskaig Conglomerate, is an anticline.

(2) In the central or axial belt, where well-defined stratigraphical groups crop out along the seashore, constant repetition by isoclinal folding is non-existent, although there is important repetition by open folding and faulting. One cannot hope to determine structure with like certainty in the waste of uniform, well-bedded, fine-grained quartzite between the westernmost outcrop of the Dolomitic Group and the first appearance of the Pebbly Quartzite at Gortantoid Point. I could, however, find no evidence for isoclinal repetition of this fine-grained quartzite (the example, fig. 5, p. 51, of the Geological Survey Memoir is based on an illusory appearance), and I feel confident that the group is some thousands of feet thick on both sides of the Islay Anticline.

(3) The Upper Fine-Grained Quartzite is stratigraphically distinct from the Lower, as may be seen from its superior position and greater thickness, and more especially from its passing under the Pebbly Quartzite at Gortantoid Point. In order to clinch the matter, it may be stated in advance that the Gortantoid relation is precisely reproduced on the opposite side of the Islay Anticline in Jura.

*Inland exposures in the axial district of the Islay Anticline.*—On the west side of the inland continuation of the Bonahaven Fault, the Lower Fine-Grained Quartzite dips in a general northward direction away from the Portaskaig Conglomerate. The junction of the two groups is often hidden, and the bedding of the quartzite is sometimes rather difficult to make out; consequently it is fortunate that additional evidence, leaving nothing to the imagination, is afforded by the upward passage of the quartzite at gentle angles under the Dolomitic Group. A traverse along the southern boundary of the latter, from Loch Staoinsha (2 miles south-west of Bonahaven) to beyond Giur-bheinn, reveals a simple anticlinal arrangement[1] of the beds, affected by a regular northerly pitch, and complicated to some extent by faulting. The fault, which runs through Loch Giur-bheinn (a small loch immediately east of Giur-bheinn), is bordered at the loch by steeply-inclined beds along its western side. Although these beds are on the upthrow side of the fault and dip towards it, they appear to be inverted. Be this as it may, the effect is strictly local, and the dip speedily rights itself.

It is interesting to note, in passing, a recurrence of conglomeratic conditions towards the top of the Lower Fine-Grained Quartzite in these inland exposures [7, p. 43], just as in the coast-section already described. The bed or beds contain nordmarkite and other pebbles like those of the Portaskaig Conglomerate, but the matrix is sometimes a pebbly quartzite. West of Giur-bheinn considerable outcrops of gritty slate are shown in Pl. XII as belonging to this conglomeratic position; it is not certain, however, that they do not belong to the Dolomitic Group. In the neighbourhood of Giur-bheinn the massive quartzite intercalation ('Pipe-Rock' of the

[1] Reference is made to this anticline in the Geological Survey Memoir on Islay (p. 49) as 'by far the most conspicuous example of the system of folding,' and evidence for it is given in some detail.

Geological Survey Memoir), which occurs towards the base of the Dolomitic Group on the coast, is strikingly developed, and serves as an excellent index.

In most of the inland tract under consideration the existence of the Islay Anticline is very obvious, because, just as in the coast-section, the dips are practically all normal. About a mile south of Giur-bheinn, however, the western limb of the anticline becomes steeply overturned.

The Dolomitic Group has a double outcrop in the western limb, as a result of repetition by faulting. In the more easterly of these two outcrops the quartzite intercalation ('Pipe-Rock' of the Survey Memoir) is often traceable, but in the other outcrop I could not be certain of its presence. In their northern portions both outcrops afford quite typical exposures of the Dolomitic Group; towards the south, especially in the western outcrop, exposures are mainly limited to massive beds of very pale-grey dolomite.

It is a curious feature in the tectonics of this western limb that the two outcrops of the Dolomitic Group remain equidistant when followed from the district of normal dips into that of steeply-reversed dips. It looks as though the fault, repeating the group, is of comparatively low inclination in the southern part of the region. East of Loch Cam the outcrop of the fault bends abruptly south-eastwards, and very clearly truncates the Dolomitic Group (with the quartzite-band so often mentioned) and also the whole of the underlying Lower Fine-Grained Quartzite, throwing them against Portaskaig Conglomerate and Islay Limestone. The inclination of the rocks thus brought together is very steep, and, as the fault is running transversely to their strike, its existence is easily demonstrated. From this point north-north-eastwards for 4 miles the fault has been mapped parallel to the strike of the beds, merely so as to account for the observed repetition of the Dolomitic Group. A mile north-north-west of Giur-bheinn it becomes self-evident once more, for quartzite on the west of it is seen aiming directly at dolomitic rocks on the east.

In the more westerly of the two main outcrops belonging to the western limb of the Islay Anticline, all the groups between the Islay Limestone and the Upper Fine-Grained Quartzite deteriorate greatly south of Loch Cam. It is doubtful how far this is a feature of original sedimentation, and how far due to mechanical thinning connected with the Loch Skerrols Thrust. The Upper Quartzite is itself mechanically thinned out, more or less completely, in this neighbourhood and on the south.

It is unnecessary to point out in detail the evidence that the quartzite outside the cordon of dolomitic outcrops, reaching from the Bonahaven Fault to near Bridgend, must belong to a structurally overlying group—sharing, of course, in the steep inversion of the western limb of the Islay Anticline. The mapping may be allowed to speak for itself, but it should be added that the superposition of the outer quartzite is clear in the neighbourhood of the Margadale River (west of Bonahaven) and has been recognized

in the Geological Survey Memoir on Islay, where, however, it is interpreted as a local inversion.

Jura.—A full statement of my observations in Jura has been published in the Geological Survey Memoir on Knapdale, Jura, and North Kintyre. Of this a short résumé is given below.

The following succession has been recognized in the Islay Quartzite as developed in Jura, where, unfortunately, the base of the formation is not exposed. The sequence is stated in descending order:—

Scarba Conglomeratic Group.
Jura Slates—black above, grey below.
Non-Vitreous Pebbly Quartzite with seams of Black Slate.
Non-Vitreous Pebbly Quartzite with Flags, except in the south.
Vitreous Pebbly Quartzite (Pebbly Quartzite, North Islay).
Vitreous Fine-Grained Quartzite (Upper Fine-Grained Quartzite, North Islay).

As indicated in Pl. XII, two important faults pass northwards across the Sound of Islay into Jura: the more westerly merely touches the western shore of Jura; the more easterly—the Beinn Bhan Fault of Islay—runs inland for a short distance. The position of these two faults in the coastal cliffs is indicated by pronounced shattering. Between the two faults one meets with an upward succession from the Vitreous Fine-Grained Quartzite into the Vitreous Pebbly Quartzite—in fact, the same sequence exactly as one encounters along the northern shore of Islay west of the anticlinal axis.

The Beinn Bhan Fault has not been followed in the inland part of its course, where, indeed, exposures are rather unsatisfactory. It probably joins its western neighbour on re-emerging upon the coast, for there is great shattering of the quartzite at the place where the two faults are mapped as coming together; while no marked shatter-belt is seen in the coast-sections farther north.

The Vitreous Pebbly Quartzite seen west of the fault—or, at any rate, a rock of identical character—continues northwards along the coast to the mouth of the loch that almost divides Jura into two. After the interruption due to this loch, the group is seen again for some 3 miles, when it passes below the sea, to reappear once more in Scarba.

Dipping off the Vitreous Pebbly Quartzite comes the most characteristic division of the Islay Quartzite as developed in Jura—namely, the Non-Vitreous Pebbly Quartzite with Flags. It is an immensely thick group, and in the south consists almost uninterruptedly of pebbly quartzite, which, in a northerly direction, is increasingly split up by cleaved grey sandy shales (or mudstones) and flags, more or less evenly distributed throughout. In some cases, as Dr. Peach has pointed out, the flags are crowded with worm-casts.

The next group, the Non-Vitreous Pebbly Quartzite with seams of Black Slate, has only been differentiated in the north of Jura,

where its most obvious feature is an absence of the flags so characteristic of the much thicker group on the west. The quartzite is massive and not very pebbly, and has no conglomeratic tendencies. In the Survey Memoir I correlated this band with the Conglomeratic Group of Scarba; but, on further consideration, I feel convinced that the conglomeratic pebbly quartzite south-east of the Jura Slates is the true representative of the Scarba Conglomerates.

The Jura Slates, in their typical development, include a western portion of grey slate or phyllite and an eastern portion of black slate. Except in certain exposures half way up the coast, the grey slates are quite subordinate, and in the extreme north they fail altogether. In the north the black slates are accompanied by thin beds of dark-grey or black limestone, some of them pebbly.

The Scarba Conglomeratic Group, according to the correlation now adopted, dips off the Jura Slates, and consists of pebbly quartzite of an unusually coarse texture, and often of a dark-grey or black hue. These coarse pebbly quartzites everywhere carry intercalations of black slate, which, so far as one can judge, increase in importance northwards.

The pebbles are generally quartz and felspar, ranging up to the size of a pigeon's egg. At a few points, indicated by dots in Pl. XII, fragments of grit and slate occur, imparting to the rocks a definitely conglomeratic facies. From the appearance of the matrix, and from the quite abnormal size of the associated quartz- and felspar-pebbles, I have no hesitation in regarding these rock-fragments as products of erosion: they have not resulted from crushing connected with the folding of the schists.

East Islay.—The following succession has been determined in East Islay:—

Scarba Conglomeratic Group.
Jura Slates, black above, grey below.
Quartzite, prevalently pebbly above, non-pebbly below.

It has already been pointed out that the Portaskaig Conglomerate can be recognized at intervals from Beinn Bhan to Port nan Gallan, near the Mull of Oa. A little to the east of its course one might expect to meet with the Dolomitic Group of North Islay. Unfortunately, however, only a single rather doubtful outcrop has so far been found. It occurs on Beinn Bhan, where it was recognized by the officers of the Geological Survey. The persistent non-appearance of the Dolomitic Group elsewhere may, perhaps, be due to an untraced continuation of the Beinn Bhan Fault; it is more likely, however, a result of a deterioration of the Dolomitic Group in a southerly direction.

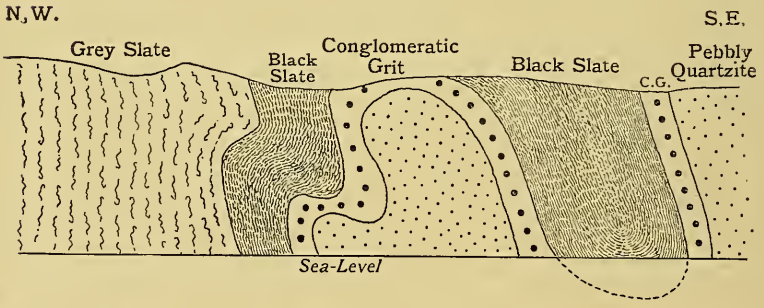
The great mass of quartzite lying north-west of the Jura Slates in East Islay is susceptible of a rough division into a lower group with few pebbly bands, and an upper group which is very generally pebbly. All the quartzite east of the Beinn Bhan Fault belongs to the pebbly group.

The Jura Slates are best exposed on the southern coast, where a broad band of grey slate is followed eastwards by a thin belt of intensely black slate. It is interesting to note how close an agreement exists between this exposure and those of Jura, save only that the grey slates are relatively more important in the south.

The Scarba Conglomeratic Group, as in Jura, is represented by pebbly quartzite, generally of extreme coarseness and sometimes definitely conglomeratic. The pebbles are quartz and felspar, along with occasional fragments of quartzite and slate. The rock-fragments are evidently a result of 'contemporaneous erosion'—the slate, no doubt, in most cases derived from interbedded seams of slate, generally grey, sometimes black.

The interbanding of quartzite and slate in parts of the Conglomeratic Group has been interpreted in the Survey Memoir on Islay as an example of incessant repetition by folding of the conglomeratic edge of the Islay Quartzite and the neighbouring pelitic

Fig. 6.—*Cliff-section, 200 feet high, on the southern coast of Islay: interfolded Jura Slates and Scarba Conglomeratic Group.*




rocks of the Port Ellen Phyllites. The slate-fragments have accordingly been taken as conclusive evidence that the Islay Quartzite is of later date than the Port Ellen Phyllites. But, as a matter of fact, the supposed repetitions can nearly always be distinguished one from the other on the score of minor characters, such as colour, composition, or texture; wherefore it seems certain that they are mostly due to recurrences of type in an originally alternating series of arenaceous and argillaceous deposits. At the same time, with the incoming of softer strata between the quartzite-beds there is a marked increase of buckling, such as is illustrated in fig. 6, above.

A particularly interesting section of that portion of the Scarba Conglomeratic Group which comes next to the Jura Slates is furnished by the cliffs of the southern coast of Islay. The black slate of the Jura Slates is here seen folded with the succeeding quartzite of the Conglomeratic Group in the manner indicated in fig. 6. The quartzite, where it approaches the black slate, is

markedly coarse in texture, blackish, and charged with black-slate fragments. It is, therefore, exceedingly likely that the Scarba Conglomeratic Group is later than the Jura Slates. This deduction has already been drawn from the exposure, and is stated in the Geological Survey Memoir on Islay (p. 36). Unfortunately, however, the authors of that memoir regarded the Jura Slates as merely Port Ellen Phyllites, brought to the surface along an anticline, and accordingly they thought that the section showed the Islay Quartzite to be later than the Port Ellen Phyllites. On the interpretation of the stratigraphy advanced in the present paper, exactly the reverse conclusion is attained.

Scarba, Lunga, etc.—The following succession of groups has been recognized from west to east in the Islay Quartzite as developed in Scarba. Dr. Peach, to whom we owe the classification and also the recognition of worm-casts in certain of the groups, is of opinion that the succession is probably a stratigraphical one—not reduplicated by folding,—and that the Conglomeratic Group is the oldest group of the series. I agree with Dr. Peach, except that, in the light of the evidence from Islay, I think that the Scarba Conglomerates are probably the latest members of the series :—

Scarba Conglomeratic Group.
? Jura Slates (not recognized as a group by Dr. Peach, and for the greater part cut out by the Scarba Fault).
Pebbly Quartzite with numerous Flags (sometimes crowded with worm-casts).
Massive Quartzite, sometimes pebbly, with quartz and felspar.
Fine-Grained Quartzite, with concretions resembling the infilled mouths of worm-pipes.
Quartzite with Flags (sometimes crowded with worm-casts).

It seems not improbable that the western Quartzite with Flags of Scarba may belong to the upper part of the Dolomitic Group of Islay. The eastern Quartzite with Flags is, of course, the continuation of the Jura Flag Group; while the Massive Quartzite on the west of it belongs to the belt of vitreous quartzites which occupies the western coast of Jura for about 7 miles.

The eastern Quartzite with Flags is bounded on the east in Scarba by an important fault, recognizable also in the islands on the north, where it increases considerably in downthrow. In those portions of the northern islands that lie west of the Scarba Fault (leaving out of consideration the Garvellachs and Dubh-fheith, which I have described as constituted wholly of Portaskaig Conglomerate), Dr. Peach believes that he can recognize the Massive Quartzite of Scarba and also (in Lunga) the eastern Flag Group.

It seems that the Jura Slates are wholly faulted out in Scarba, unless represented for a short distance by a strip of black slate, noted by Dr. Peach on his field-maps along the course of the Scarba Fault. In Lunga it is not impossible that the group has been locally removed by 'contemporaneous erosion,' since a fairly important outcrop of what appears to be the eastern Flag Group of

Scarba occurs in this island in the midst of the conglomeratic beds east of the Scarba Fault.

The Conglomeratic Group, as developed in Scarba and the islands on the north, is of exactly the same type as in Jura and Islay, but with the conglomeratic tendency more marked. While much of the deposit consists of coarse pebbly quartzite, it is common to find beds containing unrounded blocks of pebbly quartzite, black slate, and limestone—some of them several feet long. There are no igneous boulders such as are commonly met with in the Portaskaig Conglomerate, and the equally characteristic white dolomite-pebbles of the latter are also absent.

### (3 *f*) Port Ellen Phyllites.

East Islay.—The prevalent rock-type is silvery-grey sandy phyllite and slate, with some beds of flagstone. Certain members of the group are calcareous. The metamorphism is rather higher than in Central Islay.

The Port Ellen Phyllites are the seat of an extraordinary number of epidiorite sills, probably in some measure repeated by isoclinal folding.

South-East Jura.—The Port Ellen Phyllites of South-East Jura are, for the greater part, an extremely sandy set of grey phyllites, associated with many sheared grey sandstones. Purer phyllites occur in bands, especially in the eastern portion of the exposures, where they are much invaded by epidiorite-sills. Many of the rocks are slightly calcareous, and a few seams of limestone have been noted. Layers of black slate or phyllite are intercalated in the western part of the group.

### (3 *g*) Laphroaig and Ardmore Quartzites.

A quartzitic group, to which the above title may be applied, follows south-east of the Port Ellen Phyllites. Epidiorite-sills are common throughout, while the south-eastward dip which is characteristic of the Port Ellen district is maintained very uniformly.

The first oncomings of the group are best described as fine-grained 'poor' quartzites ('Laphroaig Quartz-Schists' of the Geological Survey Memoir on Islay, p. 28). They are so much interbedded with phyllitic material, that it is probably impossible to map them out consistently.

The portion of the group cropping out farther east consists largely of pebbly quartzite, as at Ardmore and in Texa, the island south of Laphroaig.

There is a bed of conglomerate on the western shore of Loch an-t-Sailein (3 miles east-north-east of Laphroaig), and a few little bands of dolomite are interbedded with the quartz-schists a short distance inland on the eastern shore of the same. These rocks lie west of the pebbly quartzites of Ardmore type.

### (3 *h*) Scarba Transition Group.

East of the Conglomeratic Group in Scarba lies a thick succession of interbedded black slates, quartzites, and limestones. The black slates, which are of Easdale type, are the dominant members of the group. The interbedded quartzites are often pebbly, and resemble the quartzite of the adjoining Conglomeratic Group. The yielding nature of the slates has permitted the development of much obvious crumpling.

There is scarcely room for doubt that the mixed slate and quartzite group of Eastern Scarba represents a Transition Group connecting the Islay Quartzite with the Easdale Slates. The relation of this Transition Group to the Port Ellen Phyllites and the Laphroaig and Ardmore Quartzites cannot definitely be settled, owing to lack of exposure; but it seems probable that the two sets of rocks are roughly equivalent, as one would expect from their relations to the Scarba Conglomeratic Group. Such an interpretation is in keeping with the growing importance of black slate in the Jura Slate Group which followed northwards: in the south of Islay the Jura Slates are mainly grey, whereas in the north of Jura they are entirely black.

### (3 *i*) Easdale Slates.

The Easdale Slates which build up Luing and its associated islands are carbonaceous, quite black, and very pyritous. Quartzose intercalations are rare, but thin black limestones common.

As might be expected from their composition, the Easdale Slates are thrown into numberless small-scale folds.

### (4) Rocks of Degnish and Shuna.

The schists of Degnish and Shuna probably belong to the Loch Awe rather than to the Islay region. They are dealt with in the present paper, so as not to leave a gap between the district here described and that already discussed in the Journal of this Society (vol. lxix, 1913) under the title of the Loch Awe Syncline.

### (4 *a*) Degnish Limestone.

Dr. Peach has traced a very well-characterized dark sandy limestone through Degnish and Shuna into Reis an-t-Sruith—an island off Craignish Point. Much of the limestone is mottled with round aggregates of dark calcite, in large crystals, embedded in a sandy calcareous matrix.

Dr. Peach describes a narrow belt of Easdale Slates as generally recognizable in Degnish and Shuna, separating the limestone from the adjacent Ardrishaig Phyllites: in this I think that he has been mistaken. After careful re-examination I consider that the rocks in contact with the limestone are members of the Ardrishaig Group, that the junction is a normal sedimentary one, and that no Easdale Slates occur anywhere in Degnish or Shuna.

### (4 *b*) Ardrishaig Phyllites.

The Degnish Limestone is followed eastwards, both in Degnish and in Shuna, by a set of greenish-grey phyllites with many thin intercalations of white limestone, and also, in the eastern part of Shuna, of fine-grained quartzite. Lithological character and geographical position assign these rocks to the Craignish Phyllite Group, which Mr. J. B. Hill [1] several years ago correlated with the Ardrishaig Phyllites of Loch Fyne, on the other side of the Loch Awe Syncline.

## III. Conclusion.

The object of the present paper has been to give an account of the stratigraphy and structure of the Islay district. The main results are graphically expressed in Pl. XII. The map and sections of this plate speak for themselves, but a few words may be useful in regard to the explanations.

The Raised Beaches of the Loch Gruinart hollow and the lavas of Old Red Sandstone age north of Degnish are altogether later than the rocks dealt with, and are designated by black-and-white symbols.

The epidiorite-sills have no stratigraphical significance, and are shown in an isolated tablet.

To the rocks of Shuna and Degnish are assigned a separate index, because it is suspected that they may be resting upon an important thrust, separating them from the Islay succession below. The Degnish Limestone is placed under the Ardrishaig Phyllites, because it is so arranged in fact; but whether the limestone is older or younger than the phyllites is an open question.

The long index at the left-hand side of the plate represents the succession in Islay above the Loch Skerrols Thrust, and also its continuation in the islands on the north. The upper part of the index is split, in order to indicate the probable equivalence of the Port Ellen Phyllites and the Laphroaig and Ardmore Quartzites in the south to the Scarba Transition Group in the north. There is very good reason to believe that the index represents the rocks in their original order of superposition, with the oldest at the bottom.

The Bowmore Sandstone is given an index to itself, on account of its structural isolation.

The rocks of the Rhinns of Islay and Colonsay are cut off from the rest of the district by the Loch Gruinart Fault They are shown in a single index, but with the unconformity between the Lower Torridonian sediments and the Lewisian Gneiss quite clearly indicated.

Finally, it may be pointed out that the Loch Gruinart Fault is probably the Great Glen Fault of the mainland, while the Loch Skerrols Thrust is not unlikely the Moine Thrust of the North-West Highlands (see fig. 3, p. 138).

[1] 'On the Progressive Metamorphism of some Dalradian Sediments in the Region of Loch Awe' Q. J. G. S. vol. lv (1899) p. 479.

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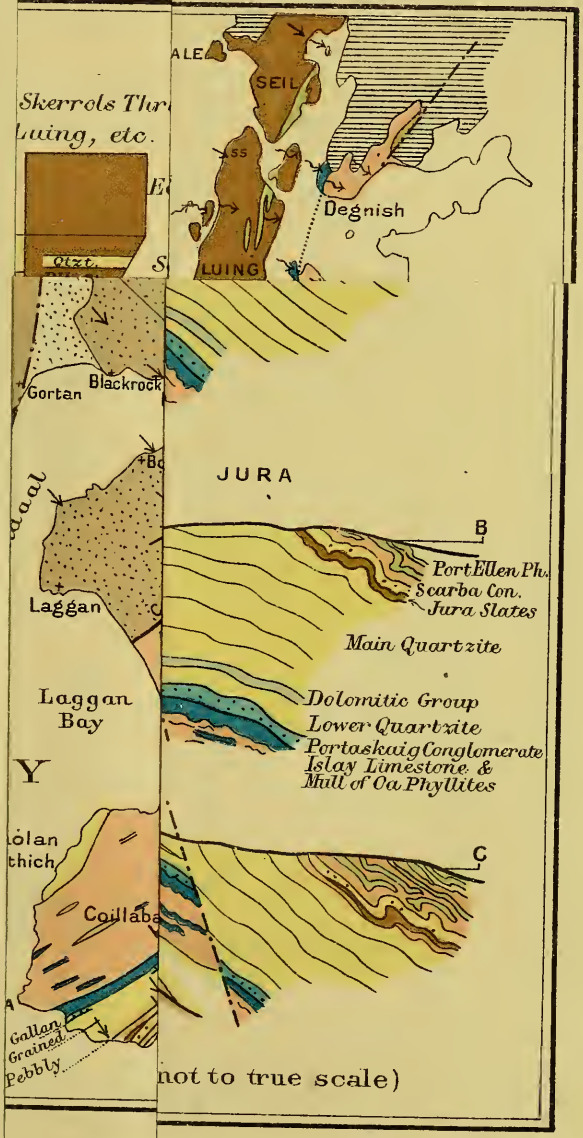
inor modifi of Scotland),

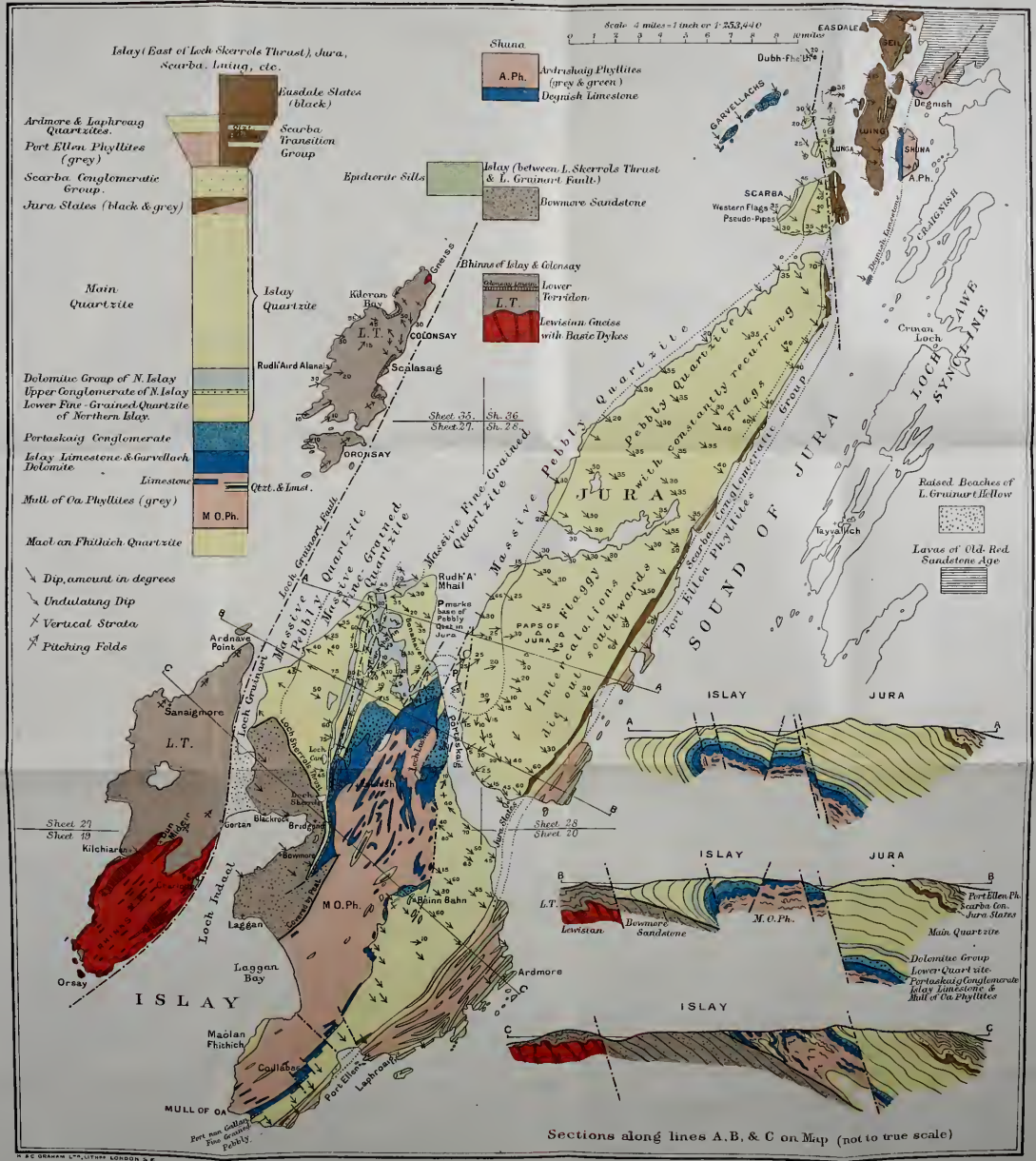



not to true scale)

# GEOLOGICAL MAP OF ISLAY, JURA, etc.

(based, with minor modifications, upon Sheets 19, 20, 27, 28, 35, & 36 of the 1-inch Geological Survey Map of Scotland),

by E. B. Bailey, M.C., B.A., F.G.S.




W. & C. GRAHAM LTD., LITHO. LONDON S.E.

## IV. Bibliography.

1. J. Macculloch.—'The Western Islands of Scotland' vols. ii & iii, 1819.
2. R. I. Murchison & A. Geikie.—'On the Altered Rocks of the Western Islands of Scotland & the North-Western & Central Highlands' Q. J. G. S. vol. xvii (1861) p. 171.
3. J. Thomson.—'On the Geology of the Island of Islay' Trans. Geol. Soc. Glasgow, vol. v (1873–76) 1875, p. 200 (a short account was communicated to the British Association in 1871).
4. One-Inch Geological Survey Map of Scotland, Sheet 20,[1] 1896.
5. One-Inch Geological Survey Map of Scotland, Sheet 19, 1898.
6. One-Inch Geological Survey Map of Scotland, Sheet 27, 1900.
7. 'The Geology of Islay (Explanation of Sheets 19 & 27 & part of 20)' Mem. Geol. Surv. Scotland, 1907.
8. W. B. Wright.—'The Two Earth-Movements of Colonsay' Q. J. G. S. vol. lxiv (1908) p. 297.
9. One-Inch Geological Survey Map of Scotland, Sheet 36, 1909.
10. 'The Geology of the Seaboard of Mid Argyll (Explanation of Sheet 36)' Mem. Geol. Surv. Scotland, 1909.
11. One-Inch Geological Survey Map of Scotland, Sheet 28, 1911.
12. 'The Geology of Knapdale, Jura, & North Kintyre (Explanation of Sheet 28 with parts of 27 & 29)' Mem. Geol. Surv. Scotland, 1911.
13. One-Inch Geological Survey Map of Scotland, Sheet 35, 1911.
14. 'The Geology of Colonsay & Oronsay, with Part of the Ross of Mull (Explanation of Sheet 35 with part of 27)' Mem. Geol. Surv. Scotland, 1911.

The authorship of the above-mentioned Geological Survey publications—so far as it concerns the subject of the present paper—is, in the main, as follows:—4, 5, and 6: S. B. Wilkinson. 7: B. N. Peach & S. B. Wilkinson. 9: S. B. Wilkinson (Jura) & B. N. Peach (northern end of Jura, Scarba, etc.). 10: B. N. Peach. 11: S. B. Wilkinson. 12: E. B. Bailey. 13 and 14: W. B. Wright & E. B. Bailey.

## EXPLANATION OF PLATE XII.

Geological map of Islay, Jura, etc. on the scale of 4 miles to the inch, or 1:253,440; with sections across those islands (not to true scale).

[*For* 'Beinn Bahn' *read* 'Beinn Bhan'; *for* 'Coillabas' *read* 'Coillabus'; *for* 'Dubh-Fheth' *read* 'Dubh-fheith.']

## Discussion.

Mr. G. Barrow drew attention to the wide range of the Author's observations; with regard to the Moine Thrust, its position on the published maps rendered its occurrence close to Islay impossible. He agreed with the Author that there was a great break between the main part of Islay and the western and almost detached part. But, although there might be a fault as well, the changes seen in the condition of the strata as regards crystallization were due mainly to the thrust that passed along the Great Glen of the Caledonian Canal and continued through the Islay area. As in the case of the Moine Thrust, little-altered or non-crystalline rocks on the south-east side of the Thrust were driven over or on to rocks that are highly crystalline. Referring to his paper published by the Geologists' Association, and accompanied by a map in which the Highland

[1] The corners of these Sheets are shown on Pl. XII.

rocks are shown to be divisible into zones of increasing and decreasing thermal alteration, the speaker pointed out that the thrust drives the outer zone, in which there is no crystallization, on to a zone of high alteration; the absence of crystallization in a considerable part of the Highland rocks of Islay is thus no proof at all of newer age—it is natural to the thermal zone, to which they belong. The limestone is so little altered, that its original oolitic structure is locally preserved despite its great age.

He agreed with the Author that the rocks in Western Islay were of Lewisian age; but, in addition, they were part of the Highland rocks, or the series of sediments of which the Moine Gneisses formed a part, and had the more common strike of the Highland folding, north-east and south-west.

The speaker complained of the introduction by the Author of new names for rocks which had long-established names. Thus, in the south-east of the island the 'Port Ellen Phyllite' has long been known to be the 'Ardrishaig Phyllite' or 'Canlochan Schist.' This band of shale is known to continue across Scotland, and emerges on the coast to the south-east of the Portsoy Quartzite. It is more of a true shale in the latter area, and contains thinner if not fewer sandstone-bands than in Islay. Similarly, the quartzite is the well-known Highland Quartzite, which again crosses the country to Portsoy; it is also finer and thinner at Portsoy, thicker and coarser in Islay.

Again, the limestone is the Blair Athol Limestone, which also occurs on both coasts; the course of it and the Quartzite are fairly well shown on the most recent edition of Sir Archibald Geikie's 10-mile to the inch geological map of Scotland. The limestone in Islay also is affected by changing conditions; while the associated dark schist is, for the greater part, more sandy and lighter-coloured than in areas to the north-east.

With regard to the stratigraphy of the area, it is known that the side of the Quartzite on which the limestone occurs is the opposite to that on which the Ardrishaig Phyllite (Port Ellen) occurs. This was proved many years ago, although the evidence has never been published. Inspection of the map already mentioned will show that the Blair Athol Limestone crops out, more or less continuously, for many miles on the north-west side of the first outcrop of the Quartzite. On the south-east side of it another persistent outcrop occurs, of the limestone known as the Loch Tay or Pitlochry Limestone. For many years these were thought to be the same limestone; but, after a short period of mapping, the speaker found that this could not be the case, and, after a considerable 'argument,' Sir Archibald Geikie was satisfied that the new view was correct, and that they were stratigraphically on opposite sides of the Quartzite. There was no question of their not being different limestones—that was settled; it then became incredible that there could be these two limestones continuing for miles, each confined to one side only of the Quartzite, without their being stratigraphically on opposite sides of that rock. These results were embodied in Sir Archibald's Presidential Address to the Geological

Society in 1891. No one has since questioned the fact of their being separate limestones, and it is doubtful whether there is now a single modern official Survey publication in which the Loch Tay Limestone is not taken to be below the Quartzite. Had these facts been published at the time, the remarkable discussion about the Quartzite being at the top of the Series could not have taken place—it is an obvious absurdity.

Thus on the eastern side of Islay the top and the base of the Quartzite occur: the latter (as usual) is the coarser, the top being finer, often very fine and often remarkably white; this fine margin occurs on the side next the Blair Athol Limestone, and there must be in the Highlands altogether many hundred outcrops of this white margin, though, except by the speaker, they are rarely if ever mentioned. The usual erosion occurs below the limestone, and, being in a folded area, it causes the outcrop of the bed to approach and recede from the margin of the Quartzite in the usual characteristic manner seen on most modern maps. When the limestone is followed round, it is seen that the Quartzite is all one quartzite; and this is confirmed by the frequent occurrence of the typical white margin in the area some distance west of Loch Finlaggan. It is now seen that the Boulder Bed (Portaskaig Conglomerate) of this area has exactly the same relations with the limestone and quartzite as at Schiehallion, placing the identity of the various beds beyond serious doubt; the limestone is the Blair Athol Limestone. (The speaker here placed on the table the Geological Survey 1-inch maps, Sheets 27 & 55, so that the Fellows might satisfy themselves as to this identity.)

In view of what has been stated, the theory advanced by the Author that the ground between the two outcrops of quartzite is an anticline seems impossible: if, as shown, the limestone is above the fine margin of the Quartzite, it must be a tilted syncline, the structure being identical with that at Portsoy in the East of Scotland. The white margin is well seen on the ground, where the so-called 'Fucoid Beds' are shown to terminate on the map; the speaker found no trace of Fucoid Beds at the places indicated. The statement that the Author disagreed with the view that the Portaskaig Conglomerate was not the Scarba Conglomerate is not well put: the ground was mapped by Mr. Wilkinson, who held no such view, but his opinion was ignored; further, Mr. Wilkinson had no doubt that the two conglomerates are on opposite sides of the Quartzite, but he doubted whether the side on which the limestone occurs was the top.

Turning now to the sandstone south-west of the so-called 'Loch Skerrols Thrust,' the speaker thought these crucially important; he doubted the existence of the thrust at all, and believed that these sandstones are brought on by pitching of the folded Quartzite, and that small patches cross the so-called thrust and are infolded with the margin of the Quartzite. These beds, as also their relation to the limestone and Quartzite, are better seen in the Bowmore area. One now sees that these sandstones have the persistent flaggy habit and the curious persistent dip in one direction, due to singularly

perfect isoclinal folding, that characterize the Moine Gneisses; from a study of the maps, the speaker felt that there was a possibility of the original rocks, from which the more massive types of felspathic Moine Gneiss were formed, being found in this part of Islay, and this was the cause of his visit to the area. He had now little doubt that these sandstones are the rocks in question. They are practically free from any trace of crystallization, present all the characters that the unaltered representatives of the Moine Gneiss should possess, and the Bowmore area shows that they are on the fine margin of the Quartzite and, so far as the folding will allow us to see, they are between the limestone and the Quartzite: that is, they are in the position assigned to them in the speaker's paper published by the Society. Far from being of any great thickness, they were probably quite a thin group originally. Islay is thus one of the most encouraging areas in the Highlands for further examination, and is worth mapping with the minutest detail.

Dr. B. N. Peach, in the following written communication to the Secretary, stated that, while making criticisms, he would wish at the same time to state that he considered the view put forth by the Author—that the dolomitic 'Fucoid'-like beds are not the highest rocks in the Islay succession, as held by the Geological Survey, but are in turn overlain by the main quartzite, the Jura Slates, the Scarba Conglomerate, and Port Ellen Phyllites, in upward sequence — to be worthy of the closest consideration, although he felt that the Author had not brought forward sufficient evidence to establish thoroughly his contention. If this could be done, many difficulties left unsolved by the Geological Survey would be cleared up:—

'The important feature in the paper is the evidence which the Author adduces to prove a further extension of the anticlinal arrangement of the strata in Islay, east of the Loch Skerrols Thrust. This structure, in a modified form, was previously recognized by the Geological Survey. In the Memoir on 'The Geology of Islay,' it was shown that the Islay limestones, black slates, and phyllites form the core of a compound anticline extending from the Mull of Oa north-eastwards to Kiels, near Portaskaig. It was also pointed out that, between Loch Finlaggan and Port a' Chotain in Northern Islay, the strata, including five subzones, ranging from the Portaskaig Conglomerate up to the Fucoidal Beds with massive bands of dolomite, are arranged in a compound arch.

'In his paper the Author contends that the dolomitic group, which resembles the Fucoid Beds of Cambrian age in Sutherland and Ross, is not the highest member of the sequence in Northern Islay, but is overlain by an upper quartzite on the eastern and western limbs of the compound arch. On the eastern limb this upper quartzite runs from Rudh a' Mhail to Bonahaven, on the western limb from Rudh a' Bholsa to Loch Skerrols in the south. He also holds that there is an ascending sequence from his upper or main quartzite of Islay, Jura, and Scarba, to the black slates of Scarba, Lunga, and Easdale.

'I submit the following criticisms on these opinions:—

'1. In proof of the superposition of the upper or main quartzite on the east limb of the compound arch in Northern Islay, the Author states that, west of Rudh a' Mhail, the dolomitic group appears as an inlier with gentle anticlinal dips passing below the upper quartzite of Rudh a' Mhail and Port a' Chotain. In my opinion, the evidence shows that the dolomitic group does not there form an inlier, and that the Port a' Chotain quartzite underlies the dolomitic group. The horizon of the latter quartzite is proved by the occurrence in it

on its west side, of the characteristic band of conglomerate containing granitoid pebbles near the top of that zone. The fault separating the Port a' Chotain quartzite from the dolomitic beds on the west does not affect this reasoning. If there is an upward succession from the dolomitic group into the main quartzite from this supposed inlier, it can only be found on its eastern margin, where the dolomitic group with a south-eastward dip is exposed on the beach followed by the quartzites of Rudh a' Mhail. But here the dolomitic beds and the quartzites are traversed by shear-lines, showing that the original relation has been disturbed by movement.

'The evidence at the western margin of the dolomitic group of an upward passage into the quartzites of Rudh a' Bholsa on the western limb of the compound arch is also unsatisfactory—because near the margin of the quartzite the section is interrupted by a fault forming a wide shatter-belt. East of this fault, pebbly quartzites occur for a few yards in contact with the dolomitic group; but, in my opinion, these pebbly quartzites may represent the boulder-bed near the top of the lower quartzite.

'As regards the Author's statement that the Islay Anticline is apparent from the dips in his main quartzite-belts, too much reliance ought not to be placed on this line of evidence in so highly folded a region. In his own map and sections he is obliged to invoke inversions of the strata north of Loch Skerrols, where his so-called 'main (upper) quartzites' dip south-eastwards as if passing, in normal sequence, below the dolomitic group!

'2. According to the Author's hypothesis, his main quartzite is overlain by the Jura black slates, and these in turn by the Scarba Conglomerate Group in Islay, Jura, Scarba, and Lunga. If there is a succession upwards from the main quartzite in Islay and Jura, it does not extend into Scarba. For, in Scarba and Lunga, the Scarba Conglomerate contains large masses of the black slates, limestones, and pebbly grits lying to the east of it. If the black slates of Scarba and Lunga belong to the Luing and Easdale black-slate group, there can be no upward succession from the Scarba quartzite into the Easdale black slates.

'3. The Author states that black slates do not occur in the island of Shuna, between the Craignish phyllites and the Shuna limestone. Black slates occupying this position were officially mapped by him at the southern end of the island, though now repudiated by him. In my opinion, black slates occupying this position occur not only at the southern end of the island, but in the middle and at the northern end, where they were formerly wrought.

'4. In the quartzite-belt north of Loch Skerrols, and in the belt between Port nan Gallan and the Sound of Islay, the lower and upper (or main) quartzites are represented in his map and sections as coming together, without the intercalation of the dolomitic group. No explanation of this feature is given by the Author.

'5. As regards the Maol an Fhithich Quartzite, which is supposed by the Author to underlie the Mull of Oa Phyllites, I think that his conclusion is erroneous: for the junction, where exposed at the northern end, is certainly a line of fault. In my opinion, it is merely a faulted portion of the same quartzite as that which overlies the Loch Skerrols Thrust, north of Bridgend.

'6. The Author refers to the Bowmore Sandstones south-east of Loch in Daal as a fine-grained series, but in that very area there are marked pebbly bands to which reference is made in the Islay Memoir (p. 27).

'7. The occurrence of Bowmore grits and sandstones west of Loch in Daal has been questioned by the Author. These grits are to be found on the shore near Gortan schoolhouse, 1 mile north of Bruichladdich, where they show the same stage of deformation as the other rocks of the Rhinns, facts which have an important bearing on the position of his supposed Loch Gruinart Fault.

'8. Regarding the Author's suggestion that the Loch Skerrols Thrust may represent the Moine Thrust of the North-West Highlands, I wish to call attention to the fact that the rocks above and below this line of disruption in Islay are in the same low grade of metamorphism—a feature quite unknown in any region where the Moine Thrust has been mapped.

'Dr. Clough's view that the Lewisian gneiss and unaltered Torridonian rocks of Iona are separated from the highly crystalline Moine Schists of the Ross of Mull by the Moine Thrust is quite in accordance with the phenomena connected with this line of movement in the north.

'I also agree with Dr. Clough's suggestion that the position of the Great Glen Fault lies between the Ross of Mull and Colonsay, on the ground that the strata on the downthrow side of the fault are in a low grade of metamorphism, compared with the Moine Schists of the Ross of Mull and Morvern, which existed as crystalline schists before the intrusion of the igneous rocks by which they are now traversed.'

The contributions by Mr. Barrow and Dr. Peach were forwarded to the Author, who sent the following reply:

'I believe that there is good foundation for some of Mr. Barrow's views regarding the equivalence of rock-groups found in Islay and Perthshire respectively. In fact, a comparison was early initiated by Macculloch. On the other hand, I think that Mr. Barrow employs a very dangerous method when he confidently interprets the Islay structure and succession in the light of his Perthshire experience. He comes to the conclusion, for instance, that Central Islay is of synclinal structure, although, in my opinion, it is easy to demonstrate the reverse in the field. He also regards the Islay Limestone as of later date than the Quartzite, although this, too, is contrary to the local evidence.

'I do not think that the complexity of the Highland problem has been sufficiently appreciated in the past. Before a satisfactory general solution is attained, I am convinced that we shall have to accumulate careful field-observations for several years to come.

'The points raised by Dr. Peach are best considered *seriatim*:—

1. I consider the sections along the northern coast of Islay to be quite convincing in regard to structure and succession; and I believe that the descriptions given in my paper will be found to be accurate. In answer to the criticism that I have to invoke inversions north of Loch Skerrols, I should like to point out that this is not a part of the district where one would attempt to decide the anticlinal or synclinal structure of the Islay Fold as a whole. It is on a flank, whereas the northern coast exhibits the axial region.

2. Dr. Peach's second criticism is based upon the claim that the source of certain boulders contained in the Scarba Conglomerate in Scarba and Lunga can be identified on the local evidence. As a first suggestion, I think Dr. Peach's interpretation of Scarba excellent; but, in the light of the fuller evidence afforded by Jura and Islay, I am convinced that it now needs modification.

3. I mapped black slates as occurring in Shuna when I accompanied Dr. Peach to that island within a few months of my joining the Geological Survey. Dr. Peach at the time told me that a particular belt consisted of "bleached black slate." Since then I have revisited Shuna, and compared the rocks in question with such small areas of bleached black slate as are sometimes found immediately adjacent to outliers of Old Red Sandstone farther north, and am convinced that a mistake was made.

4. The reason why a detailed explanation is not given, is that it is impossible to decide between the various alternatives that are available.

5. The evidence upon which my conclusion is based is given in my paper.

6. All along the Bowmore shore the sandstone is thoroughly fine-grained, as stated in my paper.

7. It is not denied in my paper that the Bowmore Sandstone may have been rightly identified on the shore near Gortan schoolhouse. The discussion of the evidence for the Loch Gruinart Fault explicitly includes this possibility.

8. The absence of highly crystalline schists immediately above the Loch Skerrols Thrust is emphasized in my paper, and is taken into account in considering the possible equivalence of the Loch Skerrols and Moine Thrusts.'